BRADLEY & NICKI

Comparison of Steam and Hot Water Heating Systems for the Present University of Illinois Campus and the Proposed Additions Thereto

Mechanical Engineering

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COMPARISON OF STEAM AND HOT WATER HEATING SYSTEMS FOR THE PRESENT UNIVERSITY OF ILLINOIS CAMPUS AND THE PROPOSED ADDITIONS THERETO

BY

EUGENE PATRICK BRADLEY
AND
FRANCIS STANLEY NICKI

THESIS

FOR THE

DEGREE OF BACHELOR OF SCIENCE

IN

MECHANICAL ENGINEERING

COLLEGE OF ENGINEERING

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May 29 1912

THIS IS TO CERTIFY THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

Eugene Patrick Bradley and Francis Stanley Nicki

ENTITLED COMPARISON OF STEAM AND HOT WATER SYSTEMS FOR THE PRESENT UNIVERSITY OF ILLINOIS CAMPUS AND THE PROPOSED ADDITIONS THERETO.

IS APPROVED BY ME AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE

DEGREE OF Bachelor of Science in Mechanical Engineering.

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LOCATION AND DESCRIPTION OF BUILDINGS.

General Descriptions.

The problem involved in this report concerns the most feasible, as well as the most economical, means of heating the group of buildings comprising the Suggested South Campus extension of the University of Illinois.

In the following pages this extension is referred to as the "South Campus"; the suggested Engineering group north of Green Street as the "Engineering Group"; and the suggested group south of Green Street to the Auditorium as the "Middle Campus". The most feasible and economical use of the available exhaust steam and the arrangement of present heating systems suggested this subdivision, into units, of the present and extended Campus.

The great distance from the Central Station to the South Campus and the condition of the present heating system, and mains, made it necessary to devise some plan by which the exhaust steam from the Central Station could be utilized for heating, in the most economical manner and with the least back pressure on the engines. To this end the following plan was adopted, considering first the hot water system.

In this report a forced hot water system is planned to serve the South Campus. The available exhaust, in excess of

that required for the South Campus, it is planned to use in a separate system of low pressure vacuum heating in the Engineering Group; the Middle Campus to be heated entirely by live steam, at reduced pressures.

This report also considers the use of steam in the entire University Group. The plan followed in this case contemplates the use of high pressure steam, for heating the South Campus; tranmission lines at 75# gage pressure, reducing to low pressure at the buildings. The Middle Campus it is planned to heat with live steam in the same manner. The exhaust steam from the central plant, it is planned to circulate at low pressure in the Engineering Group. The South Campus and Engineering Group are to be equipped with a modern vacuum heating system.

The following calculation and results need not be considered as absolutely correct, as it is only the intention to show the relative operating costs between two systems having the same maximum heating capacity as will be demanded when the Campus is developed to its ultimate maximum capacity.

Building Losses.

The plans being in a tentative state, only the general arrangement of buildings and estimated outside dimensions of same, from sketch plans of the University plat, were available. This condition made it necessary to estimate the building losses from the cubic contents of the building. No reliable recorded data could be obtained showing a relation of B.t.u.

losses per cubic foot of contents, for the prevailing type of building found on the Campus. Investigation of Professor Carpenter's Heating and Ventilating Buildings, and the thesis of Mr. W. D. Scott, 1910, furnished data used in Table I. The aim of these calculations was to obtain a ratio between the B.t.u. losses ordinarily found in this class of building per 1000 cu. ft. contents, per degree difference in temperature.

Calculations were made from actual B.t.u., condensation losses, in the Physics and Engineering Buildings, from data furnished by Mr. Scott's thesis. Relations were also found based on the amount of radiation installed in Lincoln Hall, Physics Building, Engineering Building and Agricultural Building.

In all the above, results are reduced to basis of B.t.u. losses per 1000 cu. ft. contents, per degree difference in temperature. This basis, per degree difference in temperature, is not absolutely correct in that the losses would not vary directly with the temperature, but in addition to temperature ratio losses would also depend on surface losses. The temperature ratio losses may themselves vary directly with the temperature difference, but the surface losses probably vary with the extreme differences in temperature,- i.e. the surface value of one foot of radiation may not bear the same relative proportion to one foot of glass or wall, when 70° difference in temperature, as it would when 5° difference only. Lack of experimental data giving losses for varying, prevailing inside and outside temperatures, made it necessary to

accept the rough temperature ratio theory used in practice by heating engineers. The error while not a serious one in the average size installation, might amount to a considerable in a plant so large as the one here considered.

Reviewing the results of Table I, 50 B.t.u. per 1000 cu. ft. per degree difference in temperature was finally adopted as a basis upon which to calculate the probable B.t.u. losses from the buildings in the three groups. A required room temperature of 70° F. when outside temperature is zero was adopted as sufficient for this climate. The formula as finally used was

$$C\left[\frac{50 \text{ X } 70}{1000}\right] = C \text{ X } 3.5 = \text{B.t.u. Losses per hr. per cu. ft.}$$

Tables II, III and IV give contents and losses for various buildings in each group.

References:

References were made to the following works in preparation of this report.

Professor R. C. Carpenter, Heating and Ventilating Buildings;

Proceedings of American Society of Heating and Ventilating Engineers;

Conrad Meier, Mechanics of Heating and Ventilating;

Byron T. Gifford, Central Station Heating;

N. S. Thompson, Mechanical Equipment of Federal Buildings;

N. W. Overstreet, Thesis, 1910;

W. D. Scott, Thesis, 1910

J. D. Hoffman, Heating and Ventilating.

Other Data.

In connection with the Hot Water system calculated and tabulated heat losses and steam requirements for varying out-door temperatures, have been made as follows:-

Table VIII Period 7 A.M. to 4 P.M.
Table IX Period 4 P.M. to 10 P.M.
Table X Period 10 P.M. to 7 A.M.

These periods were fixed from observing the average periods of constant, or most nearly constant, power loads on the present Power House, and begin and end at hours when the present loads usually change.

A heating season in this locality consists of approximately 205 days or 4920 hours. Of the total there are several hours during the middle of the day, in moderate weather, when no heat is required, and deducting these, approximately 360 hours, from the Period 7 A.M. to 4 P.M., we have remaining 4560 hours when heat is needed.

Column headings are self-explanatory. In Column C the B.t.u. losses for varying water and out-door temperatures are shown. Column D shows the average water temperatures for varying out-door temperatures. From these B.t.u. losses, Column C the pounds of steam required for varying out-door temperatures are obtained. Deducting the available exhaust steam gives the required live steam per hour as make up, Column G. Column H gives the number of hours duration of the different out-door temperatures, and these hours, multiplied by their respective steam requirements, gives the total steam consumption for each period for the season, shown in Column I.

Calculations for steam consumptions for steam heating were conducted along the same lines, except that on the South Campus and Middle Campus, where live steam is used entirely, the calculations are not made for separate periods as for water, but the system is considered as "running full" at all times and a deduction of 35% made in steam consumption, for saving by heat regulation.

In a steam heating system the water of condensation returning to the Power House loses considerable of its sensible heat and would not return at a temperature exceeding 190°. With a vacuum system, the temperature is necessarily much lower than this, as it would be impossible to hold a vacuum unless the water is cool enough to prevent re-evaporation. It is usually found that the temperature ranges from 90° to 140°.

It was assumed in this case that the condensation was returned to the Power House at 140° and that the water must be raised to a feed water temperature of 212°, which is the temperature of condensation, if the steam was condensed in the Power House, as is done in the water system. The cost of raising to this temperature, being caused by the loss due to the heating system, would be charged against same.

As it will require 1 B.t.u. to raise one pound of water one degree F., it will require 72 B.t.u. to raise every pound of condensation from 140° to 212° and reducing this loss of heat to an equivalent in pounds of steam per hour we have the additional steam required to charge to the steam system.

Pipe Lines.

Sizes of hot water main lines and branches were obtained from charts on flow of water in forced hot water circulation systems by Konrad Meier.

Sizes of steam mains and branches were calculated from the Babcock formula

$$w = 87\sqrt{\frac{D(p_1 - p_2)\,d^5}{L\left[1 + \frac{3.6}{d}\right]}}$$

w = weight in pounds avoirdupois

d = diameter of pipe in inches

D = density or weight per cu. ft.

p_1 = initial pressure

p_2 = pressure at end of pipe

L = length of pipe in feet.

Sizes obtained from above were checked on Konrad Meier's chart on flow of steam through pipes.

Main pipe line losses were calculated from actual square feet of radiating surface in mains, considering main laid in concrete trenches or tile pipe and covered with 1 1/2" of covering. From Cifford's Central Station Heating Coefficients for such underground, and similar covered main lines ran 50 B.t.u. per square foot for steam and 25 B.t.u. per square foot for hot water.

Exhaust Steam Available.

Amount of exhaust steam available was estimated from the University Central Station log sheets. Pump exhausts used for heating could only be estimated, no actual test data on

steam consumptions of these units being available. It was estimated that a plant approximately three times the size of the present plant would be required to care for lighting and power load of the suggested plan. The auxiliary plant would probably be one and one half the size of the present plant.

Available exhaust steam was estimated on this data. It was assumed that any additional engine equipment would be of high class four-valve type, of low steam consumption per I.H.P.

Tables V. VI. VII. show amounts of exhaust steam available for different periods of the day, and also show how these amounts were estimated.

Comparison of Water and Steam.

There are many cases where steam is preferable to hot water but in this plant, a forced circulation hot water system may be recommended for the following reasons.

The buildings are located at a great distance from the Power House, and are so scattered, and at such varying levels, as would require the installation of mechanical apparatus at several points along the system, to properly return the condensation from a steam system.

These mechanical appliances, whether return pumps, return traps or vacuum apparatus, require constant attention and repairs, and depreciation on all such specialties is rapid, so that maintenance and depreciation make them an expensive item in the cost operation.

Less heat is dissipated from piping with hot water at an

average temperature of 160° than with steam at 212°, and hot water is best adapted to undulating ground, the mains following the contour of the surface, and branch main and connections taken off at the highest points to prevent air pockets. Economy of operation of hot water is not dependent upon the nice adjustment of delicate parts, such as thermostats, thermostatic valves, etc. and the same efficiency is maintained year after year.

Inability to properly control the temperature in a building heated by steam, due to the fact that the temperature of the steam cannot be varied to suit varying outside temperatures, results in overheating the buildings and a considerable waste of heat through the necessity of opening windows.

With all systems of heating the radiating surface is proportioned to obtain the desired room temperature at minimum outside temperature and with all radiation in use. Steam as the heating medium, must entirely fill the system at a temperature of 212°, requiring a large amount of heat. The average outside temperature during the usual heating season of 205 days is 33° F., hence on the majority of days only a small amount of heat is required, and hot water will distribute this evenly throughout the entire system. The control of temperature is as near perfect as is possible to obtain. The circulating water leaves the Power House at the temperature required by the prevailing outside temperature. The water may be run at any desired temperature and is at all times under the control of the engineer at the Power House, who so regulates it as to maintain the desired temperature in the building, without

overheating. The larger line losses which occur at the higher temperatures are limited to a few days only, of the heating season. The flexible control Hot Water offers minimizes the steam consumption at the Power House, that due to overheating and that due to high temperature line losses, which a steam system always running full cannot prevent, except in the saving due to hand or automatic regulation.

While the hot water system shows better fuel economy, and attractive operation advantages, steam too has advantages that are worthy of consideration.

A steam system will be lower in first cost than a water installation.

Both systems may be adapted to the operation of plenum systems for ventilation, etc.,but steam may be a more satisfactory medium for this class of work.

A high pressure steam system as suggested will provide a ready and available supply of high pressure steam at the buildings for experimental purposes, heating water, cooking, steaming, pumping and other purposes. But it is hardly probable that it would pay to carry pressure on the large mains during periods when no heat is desired,, just to serve these purposes. A separate high pressure line for these demands would be the more practical, convenient and economical plan.

The South Campus extension will be spread over a considerable period of time, thus this system could be developed off the present system, obviating the necessity of installing mains of larger capacity than necessary for the load during the

development period. When the plan is sufficiently developed, or when the mains serving the present group with the South Campus addition, are overloaded to an extent to justify the installation of separate mains to the outer group, this work can be done with an assurance that they will be operating nearer their ultimate capacity when installed.

A summary of the fuel consumption shows a balance in favor of the Water System (See Table XVI). which on the basis of $1.25 per ton for coal amounts to $8162.50, which would represent 6% income on $136,000.00

The difference in the approximate first costs of the two systems shows a saving of $80,000.00 in favor of the Steam System. Upon this increased cost the Water System shows an income of 10.2% per annum.

No allowance is made for excess labor in handling coal and ashes, and increased cost of maintenance of a steam system over a hot water system.

In making estimates on cost of installation no account was taken of less boiler capacity required by the hot water system, but includes all other essential apparatus.

In making estimates on the two systems the prevailing prices per square foot of direct radiation, our heat losses all being calculated on the same basis, was used.

Due allowance must be made in these estimates for the lack of any defined plans or systems for the buildings. It was assumed that the same class of installation as followed out in the newest buildings in the present group would be adopted

in the extension.

The total costs of the two systems compare favorably with the total per square foot radiation costs for such work.

TABLE I

Investigations for arriving at Method of Computing B.T.U Building Losses.

From Carpenter

C = Cubic Contents.

K = Constant for estimating square feet of Radiation.

212° = Temperature of Steam.

70° = " of Room.

1.7 - B.T.U Transmitted per. square foot per degree difference in temperature per. hour.

(212-70)1.7 = 241.4 B.T.U. Transmitted per square foot per hr.

$$\frac{C \times 241 \times 1000}{80 \times C \times 70} = 43 \text{ B.T.U. per 1000 cu ft. per degree diff. temp}$$

From Thesis of W. D. Scott, 1910.

Physics Building.

3.714.094 = B.T.U. Losses per hour from experiment (Blast Coils on)

849,550 = Cu. ft. Contents of Building

55° = Difference Temp inside and outside

$$\frac{3.714.094 \times 1000}{849,550 \times 55} = 79.6 \text{ B.T.U. per 1000 cu ft. per degree diff. temp}$$

1698,405 = B.T.U Losses per hour from experiment (Blast coils off).

47° = Difference inside and outside Temperatures.

$$\frac{1.698.405 \times 1000}{849,550 \times 47} = 42.6 \text{ B.T.U per 1000 cu. ft. per degree diff. in temp.}$$

Engineering Building

3,569,337 = B.T.U. Losses per hour from experiment.

48° = Difference inside and outside temperatures

778,100 = Cu. ft Contents of building

$$\frac{3\,569\,337 \times 1000}{778,100 \times 48} = 95.6 \text{ B.T.U. per 1000 cu. ft. per degree diff. in temp.}$$

From Carpenter

Based on square feet of radiation in buildings.

Physics Building

10,802 = Sq. ft. radiation

$$\frac{10.802 \times 241}{849.550 \times 70} = 44 \text{ B.T.U. per 1000 cu ft per. degree diff in temp.}$$

12,958 = Sq. ft. radiation including blast coils.

$$\frac{12\,958 \times 241}{849.550 \times 70} = 52.6 \text{ B.T.U. per 1000 cu. ft. per degree diff. in temp.}$$

Engineering Building

13,009 = Sq. ft. radiation

$$\frac{13.009 \times 241}{778.100 \times 70} = 58 \text{ B.T.U. per 1000 cu. ft. per degree diff in temp}$$

[illegible]

TABLE I (cont'd).

Investigations for arriving at Method of Computing B.T.U. Building Losses.

continued.

Lincoln Hall.

11,400 = Sq ft of radiation.
881,000 = Cu. ft Contents of Building.

$$\frac{11{,}400 \times 241}{881.000 \times 70} =$$ 44.6 B.T.U. per 1000 cu. ft. per degree diff. in temperature.

Agricultural Building

14,620 = Sq ft of Radiation.

1,217,500 = Cu. ft Contents of Building

$$\frac{14{,}620 \times 241}{1217.500 \times 70} =$$ 415 B.T.U. per 1000 cu. ft. per degree difference in temperature.

[illegible]

TABLES II - III - IV.

TABLE II   Cubic Contents and B.T.U. Losses   TABLE III.

South Campus Group			Engineering Group		
Building	Contents cu. ft.	B.T.U. Required per. hour.	Building	Contents cu ft.	B.T.U Required per hour.
1 Armory	B.T.U Losses Estimated from Building Plans	7,880,000 2.740 000	1	688,000	2,400,000
2 Gym	1,437,000	6 940 000	2	800,000	2 800,000
3	1.060.000	3.710.000	3 Engineering	1,300,000	4.550.000
4	899.000	3.110,000	4 Physics	1,720 000	6,020,000
5	1.222 000	4.270.000	5	2.163,000	7.560.000
6	1.222.000	4,270 000	6	2,000,000	7.000 000
7	1 060.000	3.710.000	7	620,000	2.170.000
8	1,060,000	3.710.000	8	600,000	2.100.000
9	1.222 000	4.270,000	9	1,400,000	4.800,000
10	1.222,000	4.270.000	10	1.630,000	5,700.000
11	899.000	3.110.000	11	900.000	3.150.000
12	1.060.000	3.710.000	12 Armory	451.800	1,580,000
13	481.000	1.680.000	13 Gymn.	819.800	2.860,000
14	256.000	930.000	14	480.000	1,670,000
15	660.000	2.310.000	15	800,000	2,800,000
16	1.400.000	1.690.000	16	1,000,000	3,500,000
17	620,000	2.170.000			
Green-houses	92900 sq ft Glass × 70 B.T.U.	6,500,000			

Total Building Losses 70,980.000
Radiation Main Losses 1.220.000
Total B.T.U. " 72.220.000   Total B.T.U. Losses 60,660,000

TABLE IV. Middle Campus Group.

Building	Contents cu. feet.	B.T.U Required per hour	Building	Contents cubic feet.	B.T.U. Required pe hour
1	780.000	2.730.000	7	1.785.000	6.250.000
2	1,800.000	6.300.000	8	1.688,000	5.900,000
3	1.500,000	5.250.000	9	1.625.000	5.700.000
4	1,750.000	6,130.000	10	1.625.000	5.700.000
5	1.250.000	4.380.000	11	780.000	2 730 000
6	1.300,000	4.550.000	12	1,614.000	5 660 000

Total B.T.U. Losses 59,280,000

[illegible]

TABLES V, VI, VII.

Power Loads for daily periods.

Present Power Loads		Estimated Loads on New Plant		
7 A.M. – 4 P.M.	220 H.P.	7 A.M.	4 P.M.	440 H.P.
4 P.M. – 10 P.M.	160 H.P.	4 P.M.	10 P.M.	320 H.P.
10 P.M. – 7 A.M.	110. H.P.	10 P.M.	7 A.M.	220 H.P.

TABLE V.

Exhaust Steam Available from present Plant.
Atmospheric Exhaust.

Daily Period	H.P.	Water Rate	Steam lb. per. hr.	Steam from Auxiliaries lb. per. hr.	Total Available Exhaust Steam lb. per hr.
7 A.M. – 4 P.M.	220	22	4840	5850	10,690
4 P.M. – 10 P.M.	160	27	4320	5850	10,170
10. P.M. – 7 A.M.	110	47	5170	5150	10,320

TABLE VI.

Exhaust Steam Available from New Plant

Atmospheric Exhaust.

Daily Period.	H.P.	Water Rate	Steam lb. per. hr.	Steam from Auxiliaries lb. per. hr.	Total Available Exhaust Steam lb. per. hr.
7 A.M. – 4 P.M.	440	22	9680	2700	12,380
4 P.M. – 10 P.M.	320	22	7040	2700	9740
10 P.M. – 7 A.M.	220	22	4840	2700	7540

TABLE VII.

Total Available Exhaust Steam
from Combined Plants

Daily Period	Total Exhaust Steam Available lb. per. hr.
7 A.M. – 4 P.M.	23070
4 P.M. – 10 P.M.	19910
10 P.M. – 7 A.M.	17860

HOT WATER HEATING SYSTEM
ON
SOUTH CAMPUS.

VACUMN SYSTEM OF STEAM HEATING
ON
ENGINEERING GROUP.

TABLE VIII

HOT WATER HEATING.
SOUTH CAMPUS GROUP
Period - 7 A.M to 4 P.M.

Temperatures		B.T.U. Losses per hour	Aver. Water Temp	Total lbs. Steam per hour for Heating	Available Exhaust lbs. per hour	Live Steam Required lbs per hr	Hours per Season	Total Live Steam Required lbs. per Season
out-side	Room							
A	B	C	D	E	F	G	H	I
0-10	70	72,200,000	184	75,700	23,070	52,630	6	315,780
10-20	"	65,500,000	173	67,800	"	44,730	54	2,415,420
20-30	"	58,400,000	162	60,100	"	37,030	170	6,295,[illegible]00
30-40	"	51,300,000	151	53,100	"	30,030	250	9,007,[illegible]0
40-50	"	41,900,000	136	43,400	"	20330	280	5,692,400
50-60	"	28,400,000	115	29,400	"	6330	350	2,215,500
60-70	"	10,500,000	86	10,900	"	0	375	0
TOTALS							[illegible]485	2[illegible],4[illegible]00

TABLE IX.

Period 4 P.M. to 10 P.M.

Temperatures		BTU Losses per hour	Aver-age Water Temp.	Total Steam for Heating lbs per hr	Available Exhaust Steam lbs per hr	Live Steam Required lbs per hr	Hours per Season	Total Live Steam Required lbs per Season
out-side	Room							
A	B	C	D	E	F	G	H	I
0-10	70	72,200,000	184	75,700	19,910	55,790	10	557,900
10-20	"	65,500,000	173	67,800	"	47,890	50	2,394,500
20-30	"	58,400,000	162	60,100	"	40,190	110	4,420,900
30-40	"	51,300,000	151	53,100	"	33,190	200	6,638,000
40-50	"	41,900,000	136	43,400	"	23,490	240	5,637,600
50-60	"	28,400,000	115	29,400	"	9,490	290	2,752,100
60-70	"	10,500,000	86	10,900	"	0	330	0
TOTALS							1230	22,401,000

TABLE X.

HOT WATER HEATNG.

SOUTH CAMPUS GROUP.

Period 10 P.M. 7 A.M.

Temperatures		B.T.U. Losses per hour	Average Water Temp.	Total Steam for Heating lbs. per hr.	Available Exhaust Steam lbs per hr	Live Steam Required lbs per hr	Hours per Season	Total Live Steam Required lbs. per Season
Outside	Room							
A	B	C	D	E	F	G	H	I.
0-10	70	72,200,000	184	75 700	17.860	57,840	15	867,600
10-20	"	65,500,000	173	67,800	"	49 940	75	3.745,500
20-30	"	58,4[illegible],000	162	60,100	"	42,240	180	7,603,200
30-40	"	5[illegible],300,000	151	53,100	"	35,250	315	11,103 750
40-50	"	41,900,000	136	43.400	"	25 540	360	9,194,400
50-60	"	28,400,000	115	29.400	"	11,540	430	4,962 200
60-70	"	10,500,000	86	10,910	"	0	470	0
TOTALS							1845	37,476,650

SUMMARY

HOT WATER HEATNG.

Live Steam Required per Season.

Period	Hours per Season	Live Steam Required lbs per Season
7 A M to 4 P.M	1485	25,941,700
4 P M to 10 P.M	1230	22 401,000
10 P M to 7 A.M.	1845	37,476,650
TOTALS	4560	85,819,350

TABLE XI.

EXCESS EXHAUST STEAM.

60°-70° weather.

Period	Excess Exhaust lbs per Season	Hours per Season	Total Excess lbs per Season
7 A.M. to 4 P.M.	12,170	375	4,5[illegible]3 750
4 P.M to 10 P.M	9 010	330	2 973,300
10 P.M to 7 A.M.	6,960	470	3 271,200

TABLE XII

STEAM HEATING
ENGINEERING GROUP
using Excess exhaust steam
from
SOUTH CAMPUS GROUP.

Daily Period	B.T.U. Losses per hour	Total Steam Required lbs. per hr	Hours per Season.	Total Steam Required lbs. per Season	Exhaust Steam Available lbs per season	Net Live Steam Required lbs per Season
7A.M to 4P.M	60,660,000	62400	1485	92,664,000	4,563,750	88,100,250
4PM to 10PM	60,660,000	62400	1230	76,752,000	2,973,300	73,778,700
10PM. to 7A.M.	60,660,000	62400	1845	115,128,000	3,271,200	111,856,800
TOTALS			4560	284,544,000	10,808,250	273,735,750

SUMMARY.

Total steam required for Engineering group lbs per Season [illegible]

Steam required to heat condensation from [illegible]° 2[illegible]

$$\frac{(284,544,000 \times .65)\,72}{970} = \text{-------} \quad 13,740,000$$

Total steam required lbs per season [illegible]5,[illegible]50

Saving due to Regulation

$284,544,000 \times .35 = \text{-------}$ [illegible]

Net Live steam required for Engineering group
lbs per Season 187,385,350

VACUMN SYSTEM OF STEAM HEATING
ON
SOUTH CAMPUS
AND
ENGINEERING GROUP.

TABLE XIII.

STEAM HEATING.

SOUTH CAMPUS GROUP.

B.T.U. Losses per hour	Steam Required lbs. per hour.	Hours per Season	Live Steam Required lbs per Season	Steam required to heat condensate lbs per season	Total Live Steam Required lbs. per Season
70,980,000	73,200	4560	233,700,000	17,300,000	251,000,000

Calculations.—

Steam required lbs. per hr $\frac{70,980,000}{970}$ = 73,200

Steam required lbs per season 73,200 × 4560 × .65 = 217,000,000
Allowing 35% for regulation

Main Losses 5% of total load 73,200 × 4560 × .05 = 16,700,000

Steam required to heat condensation from 40°-212° $\frac{233,700,000 \times 72}{970}$ = 17,300,000

Total live steam required lbs per season 251,000,000

TABLE XIV.

MIDDLE CAMPUS GROUP.

B.T.U. Losses per hour	Steam Required lbs. per hr	Hours per Season	Live Steam Required lbs per season	Steam required to heat condensation lbs per season	Total Live Steam Required lbs. per season
59,280,000	61,140	4560	181,500,000	20,700,000	202,200,000

Calculations

Steam required lbs. per hour. $\frac{59,280,000}{970}$ = 61,140

Steam required lbs per season 61,140 × 4560 × .65 181,500,000
Allowing 35% for regulation

Steam required to heat condensation from 40°-212 $\frac{61,140 \times 4560 \times 72}{970}$ 20,700,000

Total live steam required lbs. per season 202,200,000

TABLE XV

STEAM REQUIRED

[illegible]

Daily Period	B T U Losses per Hour	Total Steam required lbs per hr	Available Exhaust lbs per hr	Live Steam required lbs per hr	Hours per Season	Lbs Live Steam required per Season
7 A.M. to 4 P.M.	60,660,000	62 400	[illegible]	39 [illegible]	[illegible]	[illegible]
4 P.M. to 10 P.M.	60 660,000	62 400	[illegible]	[illegible]	[illegible]	[illegible]
10 P.M. to 7 A.M.	60,660 000	62 400	7 800	44 [illegible]	84[illegible]	52 [illegible]
Totals.					4560	[illegible]

SUMMARY

Total live steam required lbs per season — [illegible]

35% Saving due to regulation
$62,400 \times 4560 \times .35 =$ — 99 500 000

Total live steam required for heating lbs per season — [illegible]

Steam required to heat compensation [illegible]

$$\frac{72 (62,400 \times 4560 \times .65)}{970} =$$ — 13,74[illegible],000

Total steam required lbs per season — [illegible]

TABLE XVI

SUMMARY

SOUTH CAMPUS HEATING SYSTEMS

	lbs. per season
Net live steam required for Steam System	251,000,000
" " " " " Hot Water System	85,819,350
Saving by Hot Water System	165,180,650
Engineering Group Heating.	
Net live steam required using exhaust on South Campus	187,885,350
Net live steam required using exhaust steam from Central Station	107,590,000
Net saving in favor of Steam System	80,295,350
Net saving in favor of Hot Water System on South Campus	165,180,650
Net saving in favor of Steam System on Engineering Group	80,295,350
Net saving over entire Campus in favor of Hot Water System	84,885,300

Assuming that coal used will evaporate 6 1/2# water per pound, and one ton contains 2000 lbs.

$$\frac{84,885,300}{6.5 \text{ X } 2000} = 6530 \text{ tons saving per season}$$

ESTIMATED COSTS OF SOUTH CAMPUS SYSTEMS.

HOT WATER HEATING.

416,000 sq. ft. of radiation @ 75c per sq. ft.	312,000.00
Station equipment @ 20c per sq. ft.	83,200.00
Pipe lines to South Campus (installed)	51,000.00
Conduits - 3200 cu. yds @ 9.00	28,800.00
Covering main pipe lines	10,000.00
Expansion joints, anchors, controlling valves, etc.	10,000.00
	495,000.

Steam Heating.

294,000 sq. ft. of radiation @ 75c	220,500.00
Pipe lines to South Campus (installed)	34,000.00
Drip lines (installed)	2,000.00
Heat regulation 1200 rooms @ $40.00 per room	48,000.00
Air lines of a heat regulation (installed)	3,000.00
Conduits	29,500.00
Pipe covering	9,000.00
Vacumn Heating System 4800 rods @ 12.50 each	60,000.00
Expansion joints, anchors, controlling valves, etc.	9,000.00
	415,000.00
Saving in first cost in favor of Steam System	$80,000.00

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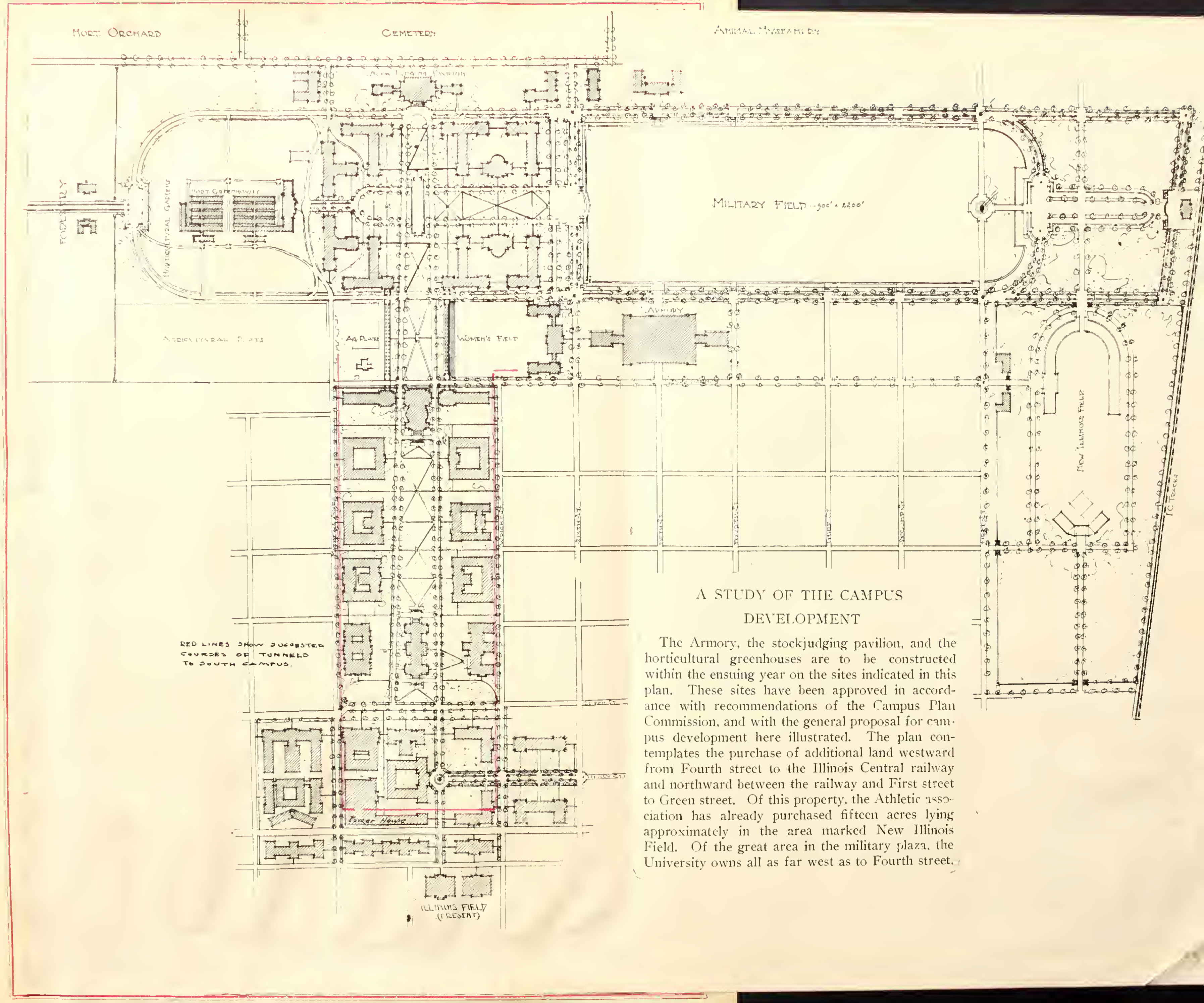

A STUDY OF THE CAMPUS DEVELOPMENT

The Armory, the stockjudging pavilion, and the horticultural greenhouses are to be constructed within the ensuing year on the sites indicated in this plan. These sites have been approved in accordance with recommendations of the Campus Plan Commission, and with the general proposal for campus development here illustrated. The plan contemplates the purchase of additional land westward from Fourth street to the Illinois Central railway and northward between the railway and First street to Green street. Of this property, the Athletic association has already purchased fifteen acres lying approximately in the area marked New Illinois Field. Of the great area in the military plaza, the University owns all as far west as to Fourth street.

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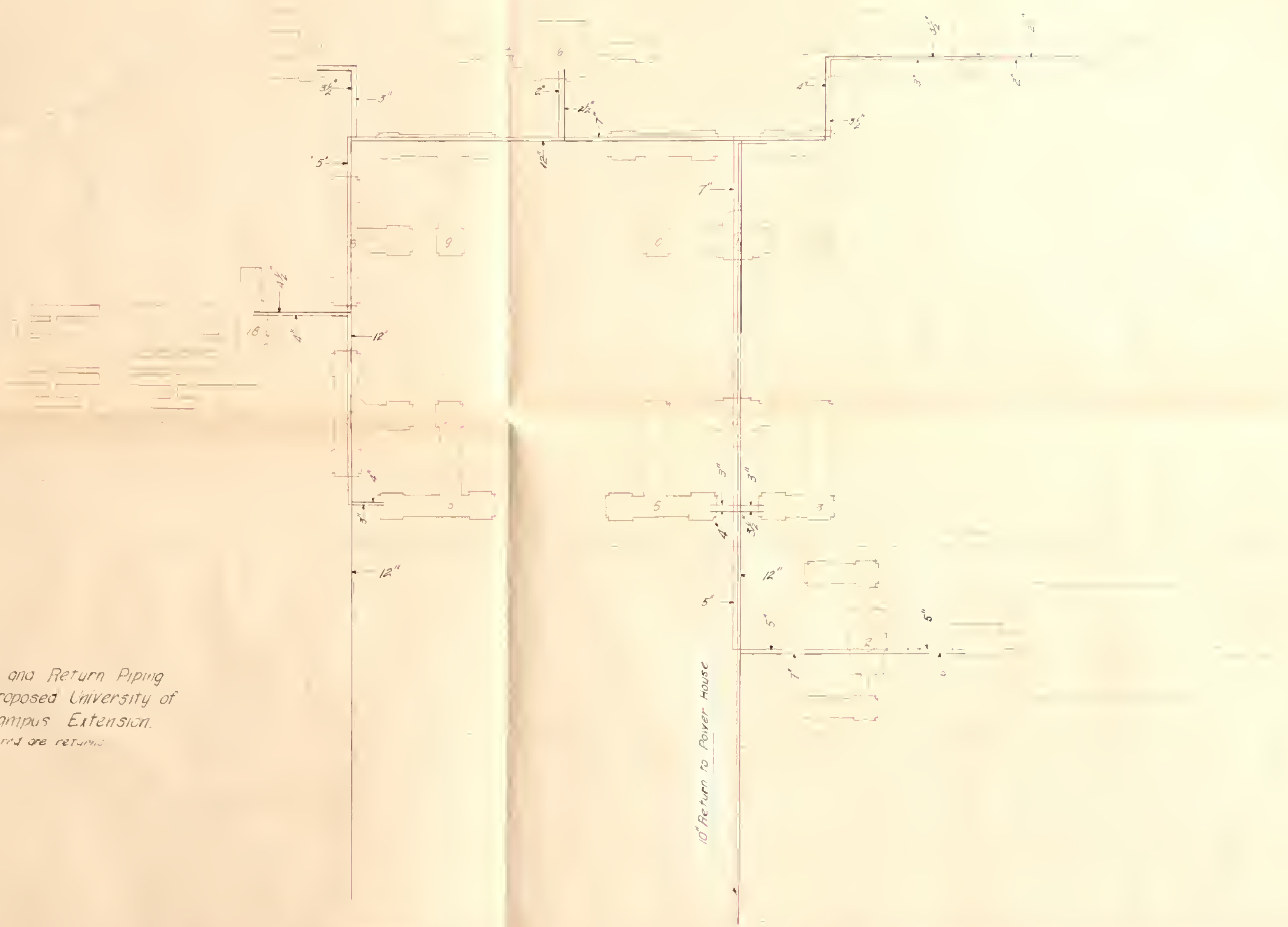

Proposed Steam and Return Piping
Lay-out for the Proposed University of
Illinois South Campus Extension.
Lines in red are returns

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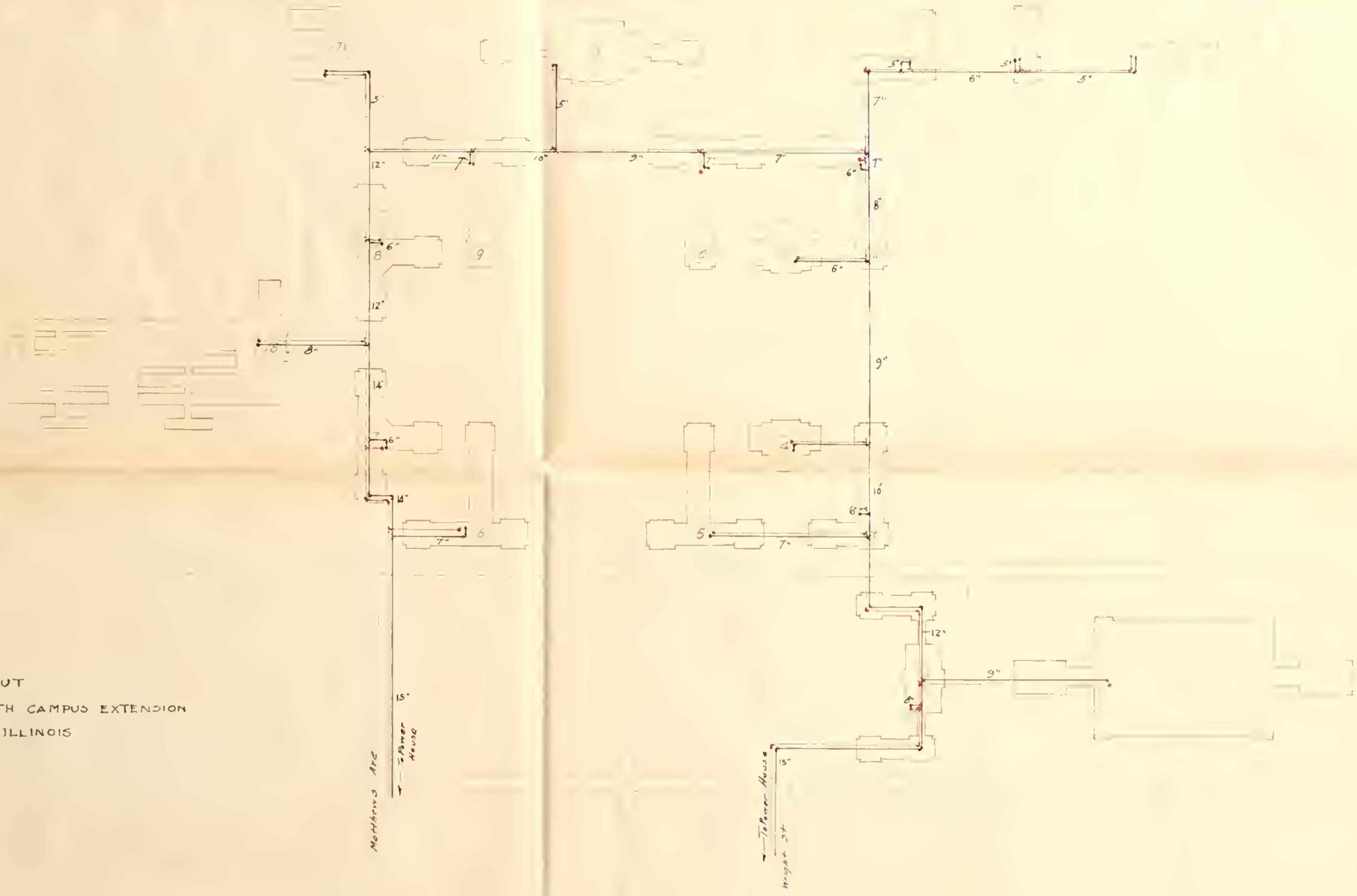

HOT WATER LAYOUT

SUGGESTED SOUTH CAMPUS EXTENSION

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Scale 200' = 1 inch

Flow –
Return –

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